Proposal for Program Revision to

Chemical Technology Program

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Community College of Philadelphia
Department of Chemistry
Chemical Technology Revision Proposal

I. Abstract

Changes to the Chemical Technology Program are being proposed in order to bring the program into compliance with the current standards of the American Chemical Society (Appendix A) and with similar programs offered throughout the country. Over twenty programs listed by the American Chemical Society were surveyed. It is proposed that this be accomplished by eliminating some courses that have become antiquated or redundant and adding courses that will shortly become available in the Applied Science and Engineering Technology (ASET) program.

II. Overview of the Existing Program

Students in the Chemical Technology curriculum receive a balanced program of practical laboratory training and theoretical concepts in inorganic, organic and analytical chemistry for the Associate in Applied Science (A.A.S.) degree. Graduates of the curriculum will have laboratory skills that will enable them to adjust quickly to industrial laboratory work (Appendix B and Appendix C). They will also have the basic foundation for further professional growth.

Students have an opportunity to use a variety of analytical instruments such as infrared, visible and ultraviolet spectrographs, vapor and liquid phase chromatography and polarography. Most of the instruments are computer interfaced. Exercises in routine instrumental analyses, as well as more challenging problems in topics such as structure determinations, are given.

The program was last revised in 2005, when Introduction to Physical Chemistry, Chem-257, which was an alternate to Environmental Chemistry, Chem-207, was eliminated. Other changes were made in the selection of electives, bringing the program into compliance with the College's general education distribution and American Diversity requirements.

III. Description of the Proposed Revision

The revision involves the elimination of Analytical Chemistry, Chem-213, and Chemical Literature Seminar, Chem-217. The essential laboratory material from the eliminated Chem-213 will be covered in an additional hour of laboratory that will be added to Instrumental Analysis, Chem-214. The remainder of the eliminated material that is still relevant to chemical technology will be covered in the newly added Introduction to Process Technology, PTEC-101, and Quality Control/Quality Assurance, ASET- 130. Safety Health and the Environment. ASET-110, would be allowed as an alternate for Environmental Chemistry, Chem-207. The number of credits will remain the same.

Course Deletions, Additions and Revisions

CHEM 213: **Analytical Chemistry (3-3-4)** Course to be eliminated.

This course covered chemical analysis with emphasis on manipulation and control of chemical systems. Chemical equilibrium, pH, data analysis, redox theory and the design of analytical procedures was emphasized. Laboratory applications included a variety of quantitative determinations such as gravimetric, volumetric, electrolytic and potentiometric analysis.

There are essentially four reasons for dropping this course from the curriculum. First, the laboratory methods listed above do not involve the use of electronic and/or computer interfaced instruments. Since this course was initially written, analytical chemistry has changed considerably. At present, very few of these methods are used in the chemical industry. Second, many of the lecture topics such as routine analysis, record keeping, sampling and quality control, will be covered in ASET-130 and PTEC-101 (see below). Third, some of the laboratory techniques, such as serial dilution and routine titration, will be covered in the additional hour of laboratory that we are suggesting be added to Chem- 214. Fourth, of the more than twenty curricula surveyed at other institutions, only one still retained this course.

ASET 130: Quality Control / Quality Assurance (3-0-3) Course to be added.

The purpose of this course is to provide students with an overview of the concepts of quality control and quality assurance. Major topics will include:

1. The definition and importance of quality control
2. The role of technicians in quality control
3. Records and documentation
4. Sampling
5. Statistical process control
6. Six sigma
7. Current Good Manufacturing Practices (cGMP)
8. ISO 9001
9. Government regulations
10. Manufacturing in a regulated environment
11. Application to different industries

This course will be a useful addition to the Chemical Technology program. It not only covers many of the topics that would have been covered in Chem-213 but also adds topics that are not now covered. Many of these new topics, listed above, discuss analytical chemistry as it applies to industry. This was lacking in Chem-213.

PTEC 101 Introduction to Process Technology (2-2-3) Course to be added

This course provides an overview of the concepts associated with Process Technology as well as an introduction to the role of Process Operators and Process Control Technicians as part of a team in the production environment. Process Technology trains people responsible for planning, analyzing, and controlling the production of products by reviewing the entire process, from the acquisition of raw materials through the production and distribution of products to customers in a variety of industries. These industries include, but are not limited to, chemical, food and beverage, oil exploration and production, pharmaceuticals, power generation, pulp and paper, refining and wastewater treatment. This course will be useful to chemical technology students because of its emphasis on the industrial process which is not sufficiently covered in the other chemistry courses.

ASET 110: Safety, Health and the Environment (3-0-3)
Students to be given the choice of ASET 110 or Chem 207

The purpose of this course is to provide students with an overview of various types of hazards that may arise in an industrial setting, as well as the engineering controls, administrative controls, personal protective equipment, and current safety, health and environmental regulations that affect these industries. Major topics that will be covered in the course include types of hazards, regulatory agencies, voluntary standards, engineering controls, administrative, controls, and personal protective equipment. This course will be useful to chemical technology students because it both provides an alternate to Environmental Chemistry, Chem-207, and includes the topics of safety and health. These additional topics will be useful to students who intend to pursue careers in multitude of industries that emphasize safety and health standards.

CHEM 214: Instrumental Analysis (**3-4-5)** Course to be revised.

This course covers the theory and application of modern instrumentation in analytical chemistry. It includes techniques in gas, liquid and ion exchange chromatography; UV, visible, IR, mass, NMR and X-ray spectrometry; and electrochemical techniques.

It is proposed that an additional hour of laboratory be added to this course to cover some of the techniques that were previously covered in Chem-213, such as simple titrations and serial dilutions. Of the more than twenty Chemical Technology curricula surveyed, all but one now cover analytical chemistry in a one semester course. In fact, textbooks are beginning to appear that answer this need. In the past, we have used the D.C. Harris text for Chem-213 and 214. Harris has now published a textbook specifically for a one semester course of this type, illustrated below:

New One-Semester Text for Chem-214

Daniel C. Harris Exploring Chemical Analysis 2009

Exploring Chemical Analysis provides an ideal one-term analytical chemistry text. Combining coverage of all major analytical topics with effective problem-solving methods, it teaches students how to understand analytical results and how to use quantitative manipulations, preparing them for the problems they will encounter in fields from biology to chemistry to geology. The new edition includes new applications throughout, more emphasis on "green chemistry," and more integration of Excel.

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CHEM 217: Chemical Literature Seminar (2-0-2) Course to be eliminated

In this course, abstract journals, bibliographies and reference works such as handbooks, dictionaries, encyclopedias and treatises pertinent to chemistry were studied. Standard reference ir, uv-vis, pmr and C-13mr spectral collections were included. Assigned library problems in organic, physical, environmental and analytical chemistry, as well as on-line literature searches,

were used for gaining experience in locating desired information. The construction of a chemical database using a computer also was included.

This course has always emphasized searching the chemical literature. The topics covered in this course, such as chemical journals, patent publications, citation indexing journals, and chemical conferences, are already being covered in other chemistry courses. At present the only thing that distinguishes the content of this course from other chemistry courses is chemical literature searching. With the current ease of searching techniques this course has become obsolete

It should also be noted that in the survey of over twenty curricula at other institutions, there were no chemistry programs, either two year or four year, now offering anything like a chemical literature course. It seems to be the consensus that the topics previously covered in this course are now spread throughout other chemistry courses.

IV. Effects of the Revision

In addition to bringing the program into compliance with current American Chemical Society standards and other similar programs throughout the country, this revision should make the program more flexible for our students. At present, there are three courses that are limited to Chemical Technology students [Chem-213, Chem-214, and Chem-217]. In the proposed program, only Chem-214 would be specific to the program. This and the fact that Chem-214 is attractive to people working in the chemical industry makes it more likely that the program can remain viable and attract new students.

If students opt to take ASET 110 instead of CHEM 207 then the number of credits needed for graduation is not changing from 62 credits. However if students take CHEM 207 then the number of credits required for graduation is 63 credits.

V. Catalog Description

Current Catalog

Chemical Technology

Course Number and Name	Prerequisites and Corequisites	Credits	Gen Ed Req.
FIRST SEMESTER			
ENGL 101 - English Composition I		3	ENGL 101
Math 118-Intermediate Algebra[1]		3	Mathematics
CHEM 121-College Chemistry I	CHEM 110 or dept head approval	4	Natural Science
Natural Science with Lab Elective[2]		4	
Course Number and Name	Prerequisites and Corequisites	Credits	Gen Ed Req.
SECOND SEMESTER			

CIS 103		3	Tech Comp
ENGL 102	ENGL 101	3	ENGL 102, Info Lit
CHEM 122- College Chemistry II	CHEM 121	4	
Natural Science with Lab Elective[2]		4	
Social Science Elective		3	Social Sciences
THIRD SEMESTER			
MATH 251- Statistics for Science [1]	MATH 118	4	
CHEM 213- Analytical Chemistry	CHEM 122	4	
CHEM 217- Chemical Literature Seminar	CHEM 122	2	
CHEM 221- Organic Chemistry I	CHEM 122	5	
FOURTH SEMESTER			
CHEM 207- Environmental Chemistry	CHEM 122	4	
Humanities Elective		3	Humanities
CHEM 214- Instrumental Analysis	CHEM 122	4	
CHEM 222- Organic Chemistry II	CHEM 221	5	
	MINIMUM CREDITS NEEDED TO GRADUATE	62	

GENERAL EDUCATION REQUIREMENTS

All General Education requirements are met through required courses (as indicated above) except for the **Writing Intensive** requirement, the **Interpretive Studies** requirement and the **American/Global Diversity** requirement**.** Therefore, in order to graduate, students in this program must choose one course that is designated Writing Intensive, one course that is designated Interpretive Studies and one course that is designated American/Global Diversity. The same course may be used to fulfill more than one of these requirements. A list of courses that fulfill these requirements and a more detailed explanation of the College's general education requirements appears elsewhere in this catalog and on www.ccp.edu.

New Catalog Description

Chemical Technology

Students in the Chemical Technology curriculum receive a balanced program of practical laboratory training and theoretical concepts in inorganic, organic and analytical chemistry for the Associate in Applied Science (A.A.S.) degree. Graduates of the curriculum will have laboratory skills that will enable them to adjust quickly to industrial laboratory work. They will also have the basic foundation for further professional growth.

Students have an opportunity to use a variety of analytical instruments such as infrared, visible and ultraviolet spectrphotometers, vapor and liquid phase chromatography, mass spectrometry, Xray fluoresence and polarography. Most of the instruments are computer interfaced. Exercises in routine instrumental analyses, as well as more challenging problems in such topics as structure determinations, are given.

The Chemical Technology Program aligns with the American Chemical Society's Laboratory Technician Employability Standards.

Student Learning Outcomes:

Upon completion of this program graduates will be able to:

- Enter the workforce as entry-level technicians in industrial, research and governmental settings.
- Demonstrate a foundational knowledge of general inorganic and organic chemistry principles and concepts and be able to apply this knowledge to the solution of problems and performance of experiments.
- Demonstrate a basic understanding of analytical and instrumental concepts and techniques and develop complementary practical laboratory skills related to the science of chemistry.
- Effectively collect, interpret, evaluate and communicate scientific data in multiple formats using computer technology as needed.

Program Entry Requirements:

This program is open to interested students, assuming space is available. The curriculum is well aligned with the courses required of students who are planning on a bachelor's degree in chemistry. Students are required to take the College's placement tests at their time of entry.

Students identified as needing developmental course work must satisfactorily complete the appropriate English and mathematics courses as a part of their degree program.

Program of Study and Graduation Requirements:

A minimum of 62 credits and a grade point average of 2.0 ("C" average) are required for graduation.

Course Number and Name	Prerequisites and Corequisites	Credits	Gen Ed Req.
FIRST SEMESTER			
ENGL-101 English Composition I		3	ENGL-101
MATH-118 Intermediate Algebra[1]		3	Mathematics
CIS-103 PC Applications		3	Tech Comp
CHEM-121 College Chemistry I	Chem-110 or Dept. approval	4	
Natural Sci. Elective with Lab[2]		4	Natural Science
SECOND SEMESTER			
ENGL-102 English Composition II		3	Engl-102 &Info Lit
MATH-251 Stat. for Science[1]	MATH-118	4	
Humanities Elective		3	Humanities
CHEM-122 College Chemistry II		4	
Natural Sci. Elective with Lab[2]		4	
THIRD SEMESTER			
Social Science Elective		3	Social Science
ASET-130 Quality Control		3	
CHEM-221 Organic Chemistry I	CHEM-122	5	
PTEC-101 Intro to Process Tech.[3]		3	
FOURTH SEMESTER			
CHEM-214 Instrumental Analysis	CHEM-122	5	
CHEM-222 Organic Chemistry II	CHEM-221	5	
CHEM-207 Environmental Chem. Or ASET-110 Safety-Envirn.[4]	CHEM-122	3/4	
Minimum Credits Needed		62[5]	

GENERAL EDUCATION REQUIREMENTS

All General Education requirements are met through required courses (as indicated above) except for the **American/Global Diversity** requirement, the **Interpretive Studies** requirement and the **Writing Intensive** requirement**.** Therefore, in order to graduate, students in this program must choose one course that is designated **American/Global Diversity,** one course that is designated **Writing Intensive** and one course that is designated **Interpretive Studies**. The same course may be used to fulfill all three requirements. A list of courses that fulfill these requirements and a more detailed explanation of the College's general education requirements appear elsewhere in this catalog and on www.ccp.edu.

For More Information Contact the Division of Math, Science and Health Careers, Room W2-7 , 1700 Spring Garden Street, Philadelphia, PA 19130, Telephone (215) 751-8431; or the College Information Center (215) 751-8010.

1. Students who qualify are encouraged to take MATH 161 or higher courses in a calculus related sequence in place of MATH 118 and MATH 251.
2. CHEM 110, 101 or 102 may not be used to meet the Lab Science Elective.
3. Experienced students may replace PTEC-101 with an elective to be selected with the approval of the Department Chair.
4. Students who opt to take ASET 110 will need 62 credits to graduate. Students who opt to take CHEM 207 will need 63 credits to graduate.
5. Students who are required to take Chem 110 prior to Chem 121 will need 66 credits to graduate.

Appendix A

American Chemical Society
ChemTechStandards
Chemical Laboratory Technician
2008

Laboratory Technician Employability Skill Standards

A. WORKPLACE SKILLS AND SUCCESS

1. Working as a member of a team
Describe the teamwork concept, analyzing, reporting, and the ethical standards in all aspects of work.

2. Problem solving
Demonstrate critical thinking skills, problem-solving, and details in observe trends.

3. Quality in the chemical laboratory
Describe the concept of "continuous improvement, quality management, and the role of the laboratory technician in implementing quality management.

4. Communication, Maintaining a laboratory notebook
Describe the protocol for keeping a laboratory notebook, writing technical reports, using spreadsheets, and conducting electronic searches. Demonstrate the ability to access database information.

5. Maintaining a safe laboratory. Environmental/health & safety regulations
Use computers to access information about procedures for chemical safety, environmental protection, OSHA regulations, Environmental Protection Agency (EPA) regulations, appropriate use of safety equipment, and fire safety activity. Describe fire potential information in a material safety data sheet (MSDS).

A. SAMPLING AND HANDLING CEMICAL MATERIALS

1. Chemical principles
Define "chemistry." Define "atoms" and "molecules"; "compounds," and "mixtures"; electronic configurations and atomic structures, Use the periodic table to identify elements and to describe atomic structure. Describe bonding and bond types, including ionic and covalent. Identify acids and bases according to the Arrhenius and Bronsted-Lowry theories. Describe the concept of stoichiometry. Calculate heat of reaction.

2. Chemical nomenclature
Use the periodic table to identify and name the elements according to symbol and group. Write names and formulas for common inorganic compounds. Write names and chemical structures for common hydrocarbons (aliphatic and aromatic, saturated and unsaturated).

3. Handling chemicals safely with proper health and environmental considerations
Classify chemicals according to safety and health hazards. Handle and dispose of hazardous materials safely and according to regulatory guidelines. Use mixing techniques appropriate for the materials, when handling acids, bases, oxidizers, and reducing agents.

4. Obtaining samples

Describe the importance of obtaining a representative sample. Give examples of samples that could result in nonhomogeniety. Use a variety of grinding, blending, and mixing techniques to prepare homogeneous samples. Conduct a statistical analysis to evaluate how well a sample represents bulk material.

5. Handling laboratory equipment safely

Describe the purpose of, and handle safely, common chemical laboratory equipment. Demonstrate a basic awareness of electrical safety and its application to the work environment. Store, transport, and change compressed gases cylinders correctly and safely. Choose the proper regulators for gases and other materials under pressure or vacuum.

B. MEASURING PHYSICAL PROPERTIES OF MATERIALS

1. Basic concepts of measurement

Describe what is meant by significant figures; give examples. Apply standard rules for significant figures. Define "precision" and "accuracy". Calculate mean, median, mode, and standard deviation. Identify, and demonstrate use of: burets, graduated cylinders, flasks, and pipets. Use electronic analytical balances for ranges from 0.001 grams to 100 grams.

2. Physical properties on materials

Describe gases, liquids, and solids in terms of their physical properties. Calculate volume, temperature, and pressure for gases, using the ideal gas law, Charles's Law, and Boyle's Law. Define physical properties, including the units and typical substances that are measured: dew point, humidity, relative humidity, and flash point.

3. Carrying out standard procedures

Recognize a variety of standard methods for measuring physical and chemical properties. State the names of the organizations represented by the acronyms and the product area for which they produce methods; the organizations include, among many others: * USP * ASTM * AOAC * EPA * IUPAC.

4. Reporting results

Using data collected from a standard method conducted by several class members, calculate precision and accuracy for several data sets. Present data graphically using a variety of presentation methods. Calculate standard deviations at 1, 2, and 3 sigma.

5. The relationship of physical properties of material to the economics of the chemical industry

Calculate economic losses that result from producing materials having off-spec physical properties. Provide examples of how companies handle off-spec material. Relate how properties of materials have economic impacts on the final product purchased by the customers.

C. PERFORMING CHEMICAL ANALYSIS

1. Reading analytical methods

Identify associations that develop and evaluate analytical methods for chemical analysis such as the American Society for Testing and Materials (ASTM), the Association of Official Analytical Chemists (AOAC), and the U. S. Pharmacopeias (USP). Examine a

method for a given analysis and report on such items as scope, detection limit, required equipment, safety considerations, calibration methods.

2. Preparing analytical solutions

Define "primary standard," list the desirable characteristics of a good primary standard, and give examples. Define and calculate solution concentration in terms of percent, normality, molarity, molality, and ppm. Calculate the amount of material required to prepare of known molarity and molality.

3. Preparing samples for chemical analysis I - getting samples into the required form

Demonstrate proper techniques for handling acids and bases. Prepare samples for analysis and describe the appropriate use of each: * grind solids using mortar and pestle, a ball mill grinder, and a mill grinder * dissolve samples in aqueous and nonaqueous solvents * acid digest samples * ash samples in porcelain and platinum containers * reflux materials.

4. Preparing samples for chemical analysis II - isolating the material to be measured

Describe the use of the following separation techniques used in chemical analysis: * filtration * distillation * evaporation * extraction * chromatography * and electrophoresis * Compare the role of the stationary and mobile phases in column chromatography.

5. Measuring pH

Relate the pH scale to acidity/basicity. Calculate pH given the hydrogen ion or hydroxide ion concentration. Calculate the hydrogen ion or hydroxide ion concentrations given the pH. Calibrate a pH meter. Measure pH using indicators, papers, and pH meters; compare the precision of these methods. Explain what a buffer solution is and describe in both general and specific terms how buffers work to control the pH of a solution.

6. Performing volumetric analysis

Select and use specific indicators to be used for acid-base titrations. Standardize solutions to be used as titrants for specific reactions. Using electrodes, perform standard procedures involving acid-base titrations. Read the endpoints from electrode potential curves. Plot electrode potential curves from a titration. Describe oxidation-reduction titrations.

7. Performing colorimetric analysis

Identify the components of a colorimeter and spectrophotometer. Apply Beers' Law to the measurement of concentration and extinction coefficients in such measurements. Select and use standards to calibrate for spectrophotometric analysis. Perform absorbance and transmittance conversions. Perform procedures using spectrophotometric methods.

8. Performing electroanalytical techniques

Describe the relationship of Faraday's Law to concentration . Balance oxidation-reduction reactions by writing half reactions. Describe how electroanalytical techniques are used in making measurements on chemical systems. Select and use ion-selective electrodes for measurement of cations or anions. Perform an electroanalytical procedure.

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D. PERFORMING INSTRUMENTAL ANALYSIS

1. Overview of instrumental analysis

Recognize that instrumental analysis can be divided into four major categories and give examples of each: * molecular spectroscopy * atomic spectroscopy * chromatography * X-ray diffraction and microscopy.

2. Troubleshooting and maintenance

Read and understand instrument manuals and follow manual directions appropriately. Recognize details of a service maintenance contract and the associated vendor relationships. Maintain an equipment log for instruments in the laboratory. Identify when a problem with an instrument requires the service of an instrument repair technician.

3. Calibration

Describe the use of calibration techniques when performing instrumental analysis. Identify the linear portion of a calibration curve. Describe the causes of nonlinearity in calibration. Use computers to prepare graphs and other calibration descriptions. Perform a calibration using standard additions and describe the value of the technique. Perform a calibration using "internal standards" and describe the value of the technique.

4. Sample preparation

Describe four (4) different techniques for preparing samples for instrumental analysis. Identify and describe the various grades of chemical reagents, including the specific characteristics required of spectrograde and/or chromatographic reagents. Demonstrate the proper care and handling of hygroscopic and/or moisture sensitive materials.

5. Principles of spectroscopy

Identify wavelength and frequency ranges of ultraviolet (UV), visible, and infrared (IR) regions. Show the relationship between wavelength, frequency, and energy. Show the relationship between concentration of and absorbance. Describe differences between the way energy is absorbed in the IR region and the ultraviolet-visible (UV-vis) region of the spectrum.

6. Molecular spectroscopy I - ultraviolet-visible spectroscopy

Write a description of the principles of UV-Visible spectroscopy, including an explanation as to what makes it useful as an analytical tool. Sketch a simple diagram of a UV-Visible spectrometer, identifying the radiation source(s), the monochromator (grating), and the detector(s) used. Using Beers' law, solve equations relating concentration to spectral absorbance in the UV and visible ranges. Demonstrate care of cells used for analysis.

7. Molecular spectroscopy II - infrared spectroscopy

Write a description of the principles of IR spectroscopy, including an explanation as to what makes it useful as an analytical tool. Identify the infrared (IR) portion of the spectrum in terms of frequency range. Solve equations relating concentration to absorbance (Beers' Law). Identify the organic functional groups most appropriately measured using IR spectroscopy. Demonstrate the proper care and handling of IR cells. Prepare samples for IR analysis using mulls, pellets, salt plates, and liquid sampling cells.

8. Molecular spectroscopy III - mass spectrometry

Write a description of the principles of mass spectrometry (MS), including an explanation as to what makes it useful as an analytical tool. Identify a variety of MS techniques (e.g. ionization, time of flight). Give examples of how various instruments are combined with mass spectrometers to form liquid chromatography/MS and gas chromatography/MS. Prepare samples for MS analysis. Predict the mass spectrum for a specified sample mixture. Analyze a variety of materials using MS.

9. Molecular spectroscopy IV - nuclear magnetic resonance spectroscopy

Write a description of the principles of nuclear magnetic resonance (NMR) spectroscopy, including an explanation as to what makes it useful as an analytical tool. Identify structural properties of materials measured using NMR. Prepare samples for NMR

analysis. Tune and calibrate an NMR instrument. . Describe hazards associated with working with NMR. Perform analyses using a proton NMR instrument.

10. Atomic spectroscopy I - X-ray fluorescence

Identify and describe the safety considerations associated with using X-ray equipment Write a description of the principles of X-ray fluorescence. Describe how X-ray fluorescence is used to analyze for elements and why one would chose it. Describe why the nondestructive nature of X-ray analysis makes it a valuable analytical technique. Conduct an analysis of a known material using X-ray fluorescence.

11. Atomic spectroscopy II - emission spectroscopy

Write a description of the principles of atomic emission (AE) spectroscopy, including an explanation as to what makes it useful as an analytical tool. Characterize spark source, flame, and inductively coupled plasmas; explain the use of each. Relate fundamentals of atomic structure and spectral lines resulting from excited in emission spectroscopy.

12. Atomic spectroscopy III - atomic absorption

Write a description of the principles of atomic absorption (AA) spectroscopy, including an explanation as to what makes it useful as an analytical tool. Use an AA method to analyze for elements in a mixture, including sample preparation, dilution, calibration, analysis, and calculation of results with accuracy and precision included. Compare a variety of AA techniques commonly used including flame, graphite furnaces, and vapor generation.

13. Chromatography I - gas chromatography

Write a description of the principles of gas chromatography (GC) as a separation technique, including an explanation as to what makes it useful as an analytical tool. Identify the components of a gas chromatograph. Relate the effects of column length and gas flow rate to separation efficiency. Use a variety of gas chromatographs (including computer controlled) to analyze known and unknown mixtures. Describe various GC detectors, including thermal conductivity (TCD), flame ionization (FID), and electron capture (ECD).

14. Chromatography II - high-performance liquid chromatography

Write a description of the principles of high-performance liquid chromatography (HPLC) as a separation technique. Identify and characterize components of a high-performance liquid chromatograph. Identify the parameters (temperature, mobile phase flow rate and viscosity, polarity, etc.) of a high-performance liquid chromatograph. Select appropriate high-purity solvents, based on polarity, and prepare HPLC mobile phases of appropriate "strength" for various separation needs. Use a variety of HPLCs to analyze mixtures. Demonstrate the integration process for calculating peak areas. Describe various HPLC detectors.

E. CONDUCTING EXPERIMENTS

1. Designing and conducting experiments

Describe the steps in the scientific method (observation, hypothesis, testing and experimentation, conclusion, and re-evaluation). Conduct literature searches pertinent to the experiment. Describe the importance of "defining the problem" when planning experiments. Demonstrate the use of a control when designing and conducting experiments

2. Introduction to organic synthesis

Define "synthesis" and give five examples of large volume industrial synthetic chemicals; define the process and synthetic steps for each. Outline the steps for conducting a synthesis to include preparation, execution, workup, product analysis, and documentation. Describe the appropriate conditions and situations in which to conduct a synthesis at various scales: large scale, small scale and micro scale.

3. Chemical reactions

Identify and name examples of the following functional groups: alkene, alkyne, haloalkane, alcohol, ether, ketone, aldehyde, carboxylic acid, ester, amide, amine, and aromatic ring. For a reaction, label the electrophile, and the nucleophile. Identify chemical equations that represent: substitution, elimination, addition, and condensation reactions. Provide examples of ten "name" reactions in organic chemistry. Provide examples of cis and trans stereoisomers, enantiomers, and diastereomers. Identify: SN1, SN2, E1, E2, redox, and electrophilic aromatic substitution reactions. Identify characteristics of the kinetics involved for first order and second order reactions.

4. Polymerization reactions

Define the terms monomer, dimer, trimer, oligomer, and polymer, and give three examples of each. Determine the formula weight of polymers. Define the following types of polymer structures and give three examples of each: linear, branched, cross linked and ladder. Define the term "copolymer" and give examples of each type: random, regular, graft and block. Identify some common commercial polymerization products.

5. Preparing to conduct a synthesis

Select and assemble appropriate glassware and equipment required for a synthesis and its workup. Prepare a synthesis plan. Obtain and purify the reagents and solvents necessary for a synthesis.

6. Conducting a synthesis

Synthesize organic compounds at large scale, small scale, and microscale technique levels. Determine the purity of reaction products using, gas chromatography (GC), high-pressure liquid chromatography (HPLC), and other instrumental techniques. Purify the synthesis products. Prepare a report that describes the experimental objective, chemical reactions, their mechanisms, literature research, processes used to perform the synthesis. Analyze the product using: (IR), (NMR), (MS), and GC-MS.

7. Molecular modeling

Utilize available molecular model kits to construct accurate three-dimensional models of selected organic compounds; provide the correct IUPAC names. Identify software specifically designed for molecular modeling. Using molecular modeling software, create several common molecular structures, calculate charges, and print in graphical format. Correlate statistical output using quantitative structure-activity relationships (QSAR).

8. Scale-up chemical reactions

Identify equipment used in a pilot plant. Describe issues associated with converting a chemical process and procedures at a pilot plant to a commercial plant scale, including the effects of kinetics, equilibrium, yields, and waste streams. Prepare a report on the differences between the laboratory-scale and the scaled-up version of the reaction.

The ChemTechStandards are provided by ChemTechLinks, the ACS project to support technician education. Funding for the development and updating of the ChemTechStandards has been provided by the U.S. Department of Education, V244B30007, CFDA #84.244,

Appendix B

American Chemical Society Statistics on Technician Employment

2008	
430,000	Approximate number of technicians employed in the United States[1]
$18,000,000,000	Total annual salary paid to technicians in the United States
130,000	Approximate number of chemists and related professionals employed in the United States
$8,700,000,000	Total annual salary paid to chemists and related professionals in the United States
$16,000/technician	Annual savings in hiring technicians from a chemical technology program[2]
37%	Percent improvement in safety incidents after hiring technicians from a chemical technology program
$1,200,000	Amount of recruiting money saved by the 40% reduction in turnover, resulting from hiring technicians from a chemical technology program
41%	Percent of employers who reported difficulty in filling positions due to talent shortage[3]
34%	Percent of current technician workforce projected to retire by 2014[4]

[1] U.S. Bureau of Labor Statistics, May 2006 data, www.bls.gov, downloaded November 2007
[2] "Industry and Education: a Winning Combination." Performance Improvement. **Jan. 1997**, p. 18-20
[3] "Talent Shortage Survey." Manpower, Inc. white paper. March 2007. www.manpower.com/research/research.cfm; downloaded May 2007
[4] U.S. Bureau of Labor Statistics, May 2005 data, www.bls.gov, downloaded April 2007

Appendix C

Community College of Philadelphia

Industry Report 2008

EMSI

Economic Modeling Specialists, Inc. www.economicmodeling.com

Region Info Region: 42101 (Philadelphia)

Executive Summary

Selected Industries
Testing laboratories (NAICS 54138)

Basic Information	
2004 Industry Jobs	225
2014 Industry Jobs	243
Total Change	18
Total % Change	8.01%
2007 Average Earnings/Worker	$78,521

Selected Occupations	Education Level
Environmental science and protection technicians, including health (SOC 19-4091)	Associate's degree

Basic Information	
2004 Occupational Jobs	370
2014 Occupational Jobs	399
Total Change	29
Total % Change	7.84%
2007 Median Hourly Earnings	$17.92

Economic Indicators	
2004 Location Quotient	0.99
2014 Location Quotient	0.89